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Johansson

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(54) **HYDRAULIC ROTATING AXIAL PISTON ENGINE**

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(30) **Foreign Application Priority Data**

Feb. 13, 1998 (SE) 9800412

(51) **Int. Cl.**[7] **F04B 7/04**; F04B 39/10
(52) **U.S. Cl.** **417/499**; 417/269
(58) **Field of Search** 417/269, 63, 485, 417/499; 91/499, 506; 92/129

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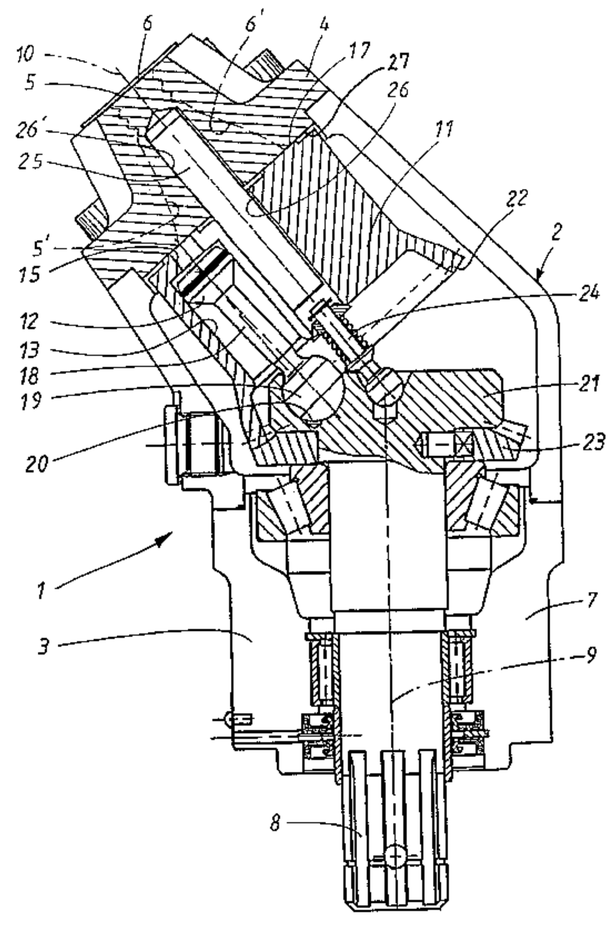
(57) **ABSTRACT**

A hydraulic rotating axial piston engine having a housing, enclosing a cylinder barrel journaled in the housing for rotation around a barrel axis. The housing also has a number of circumferentially arranged cylinders with a number of pistons reciprocating between two defined end positions. The pistons cooperate with an angled plate in order to obtain the reciprocating movement. The axial piston engine has an input/output shaft, and the cylinder barrel has channels connecting each cylinder to port(s) in the cylinder barrel. The ports alternatively act as inlet and outlet ports. The housing has an inlet and outlet channel, each having a kidney-shaped port, facing towards the inlet and outlet ports of the cylinder barrel. The kidney-shaped ports communicate with a number of the ports at the barrel. The cylinder barrel ports extend in both directions outside the cylinders in the two circumferential directions of the cylinder barrel. The channels open to the cylinders along the peripheral wall of each cylinder, and the opening to the cylinders has substantially the same area as the area of the ports of the barrel.

5 Claims, 9 Drawing Sheets



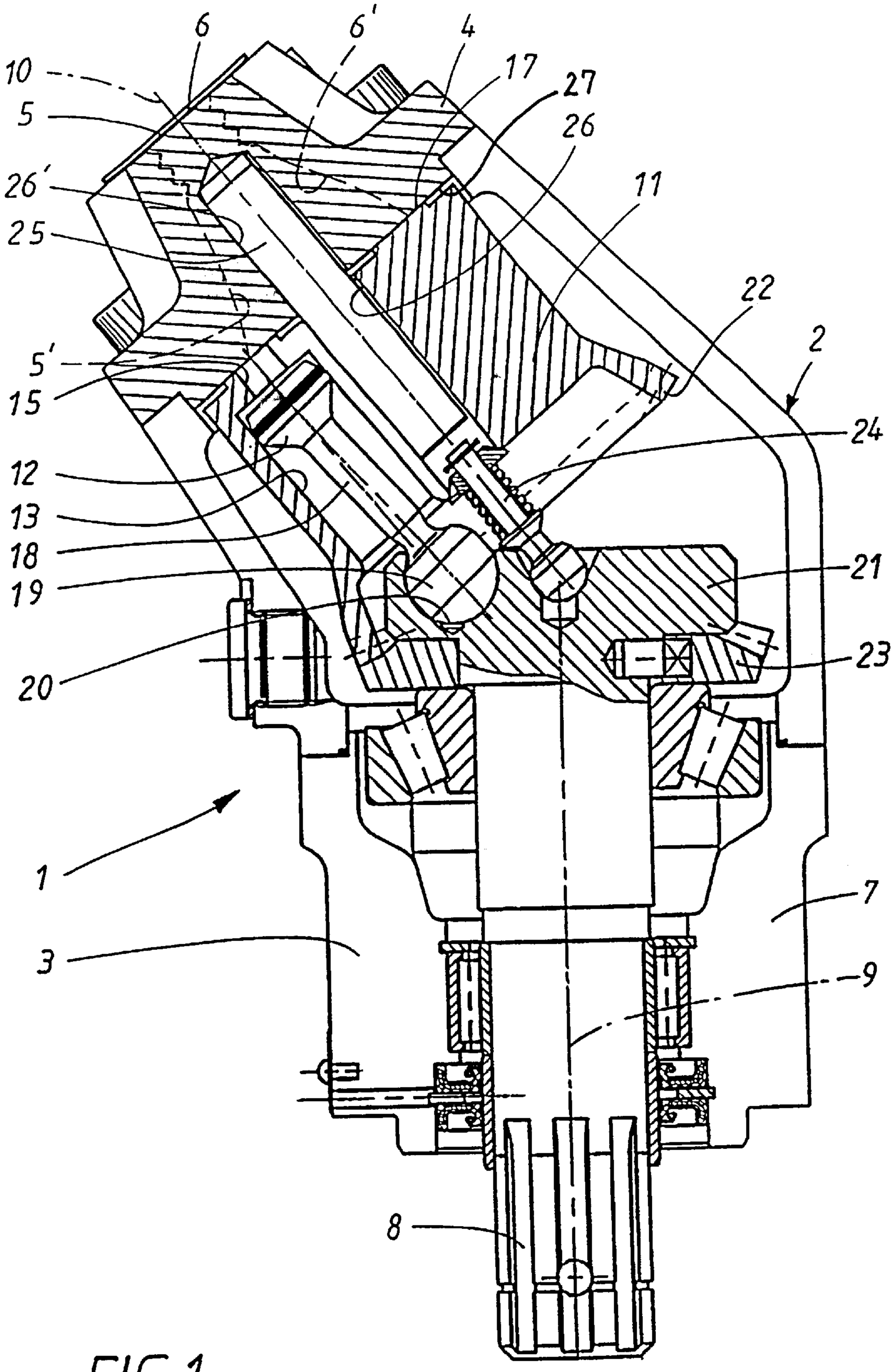


FIG. 1

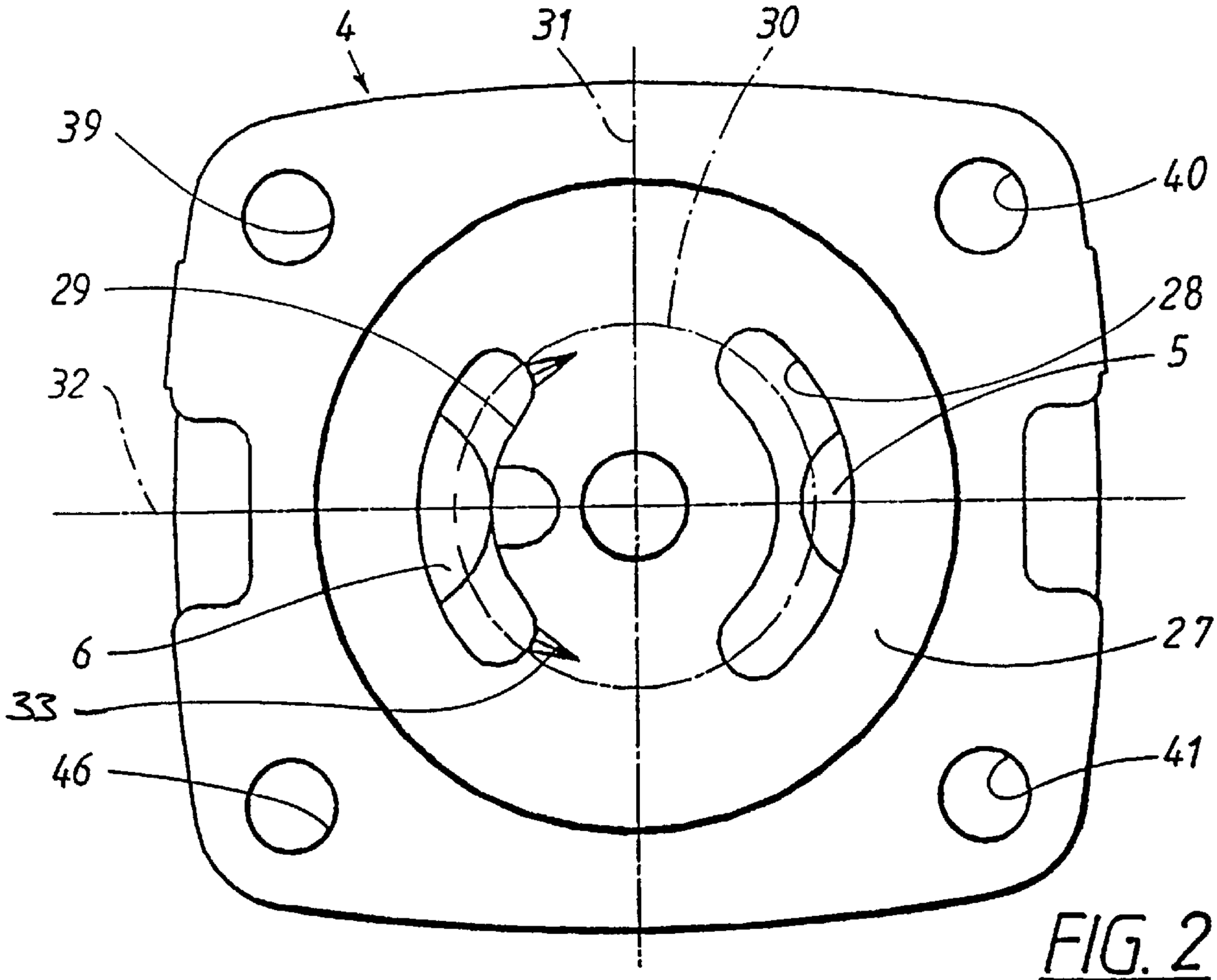


FIG. 2

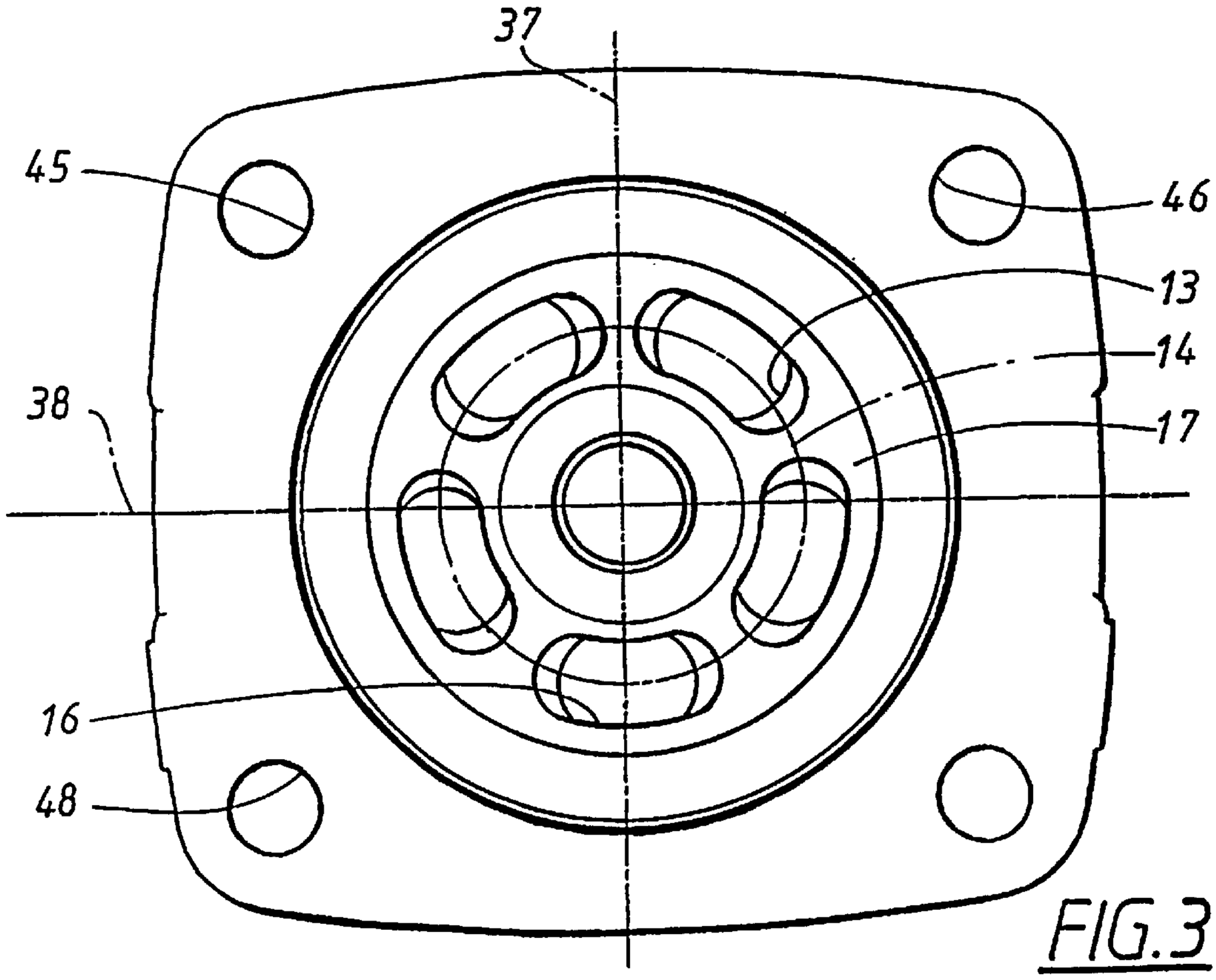


FIG. 3

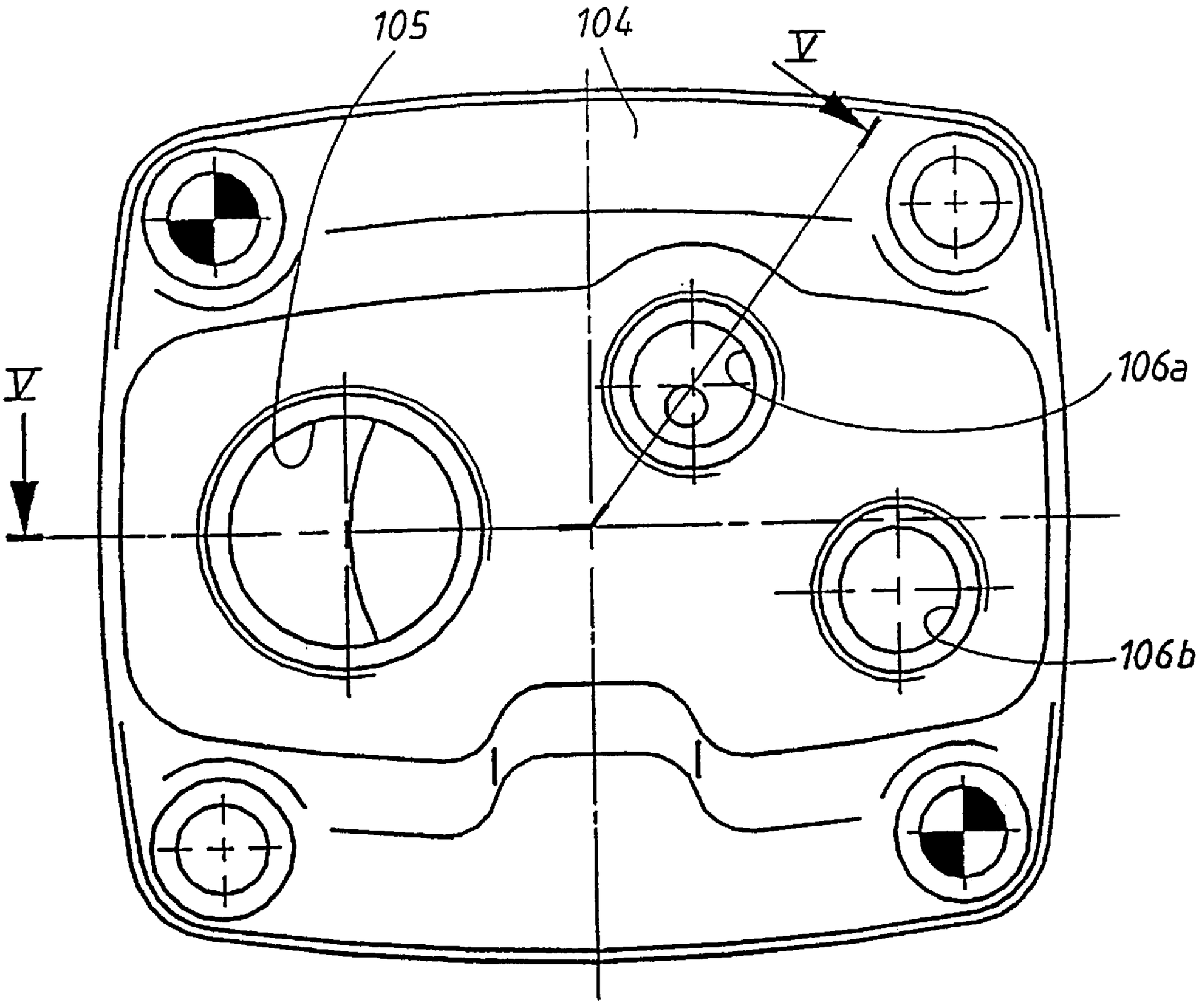


FIG.4

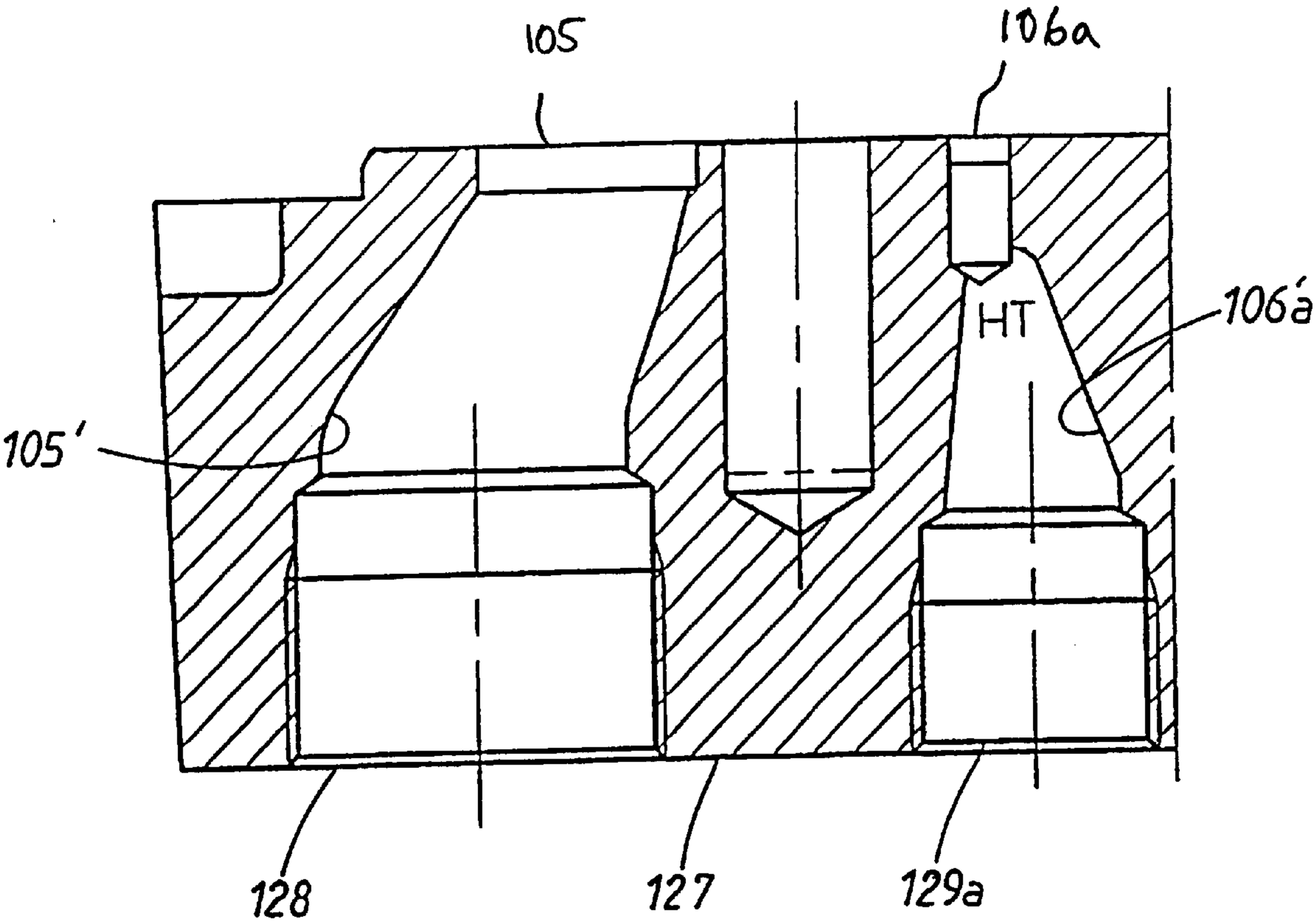


FIG.5

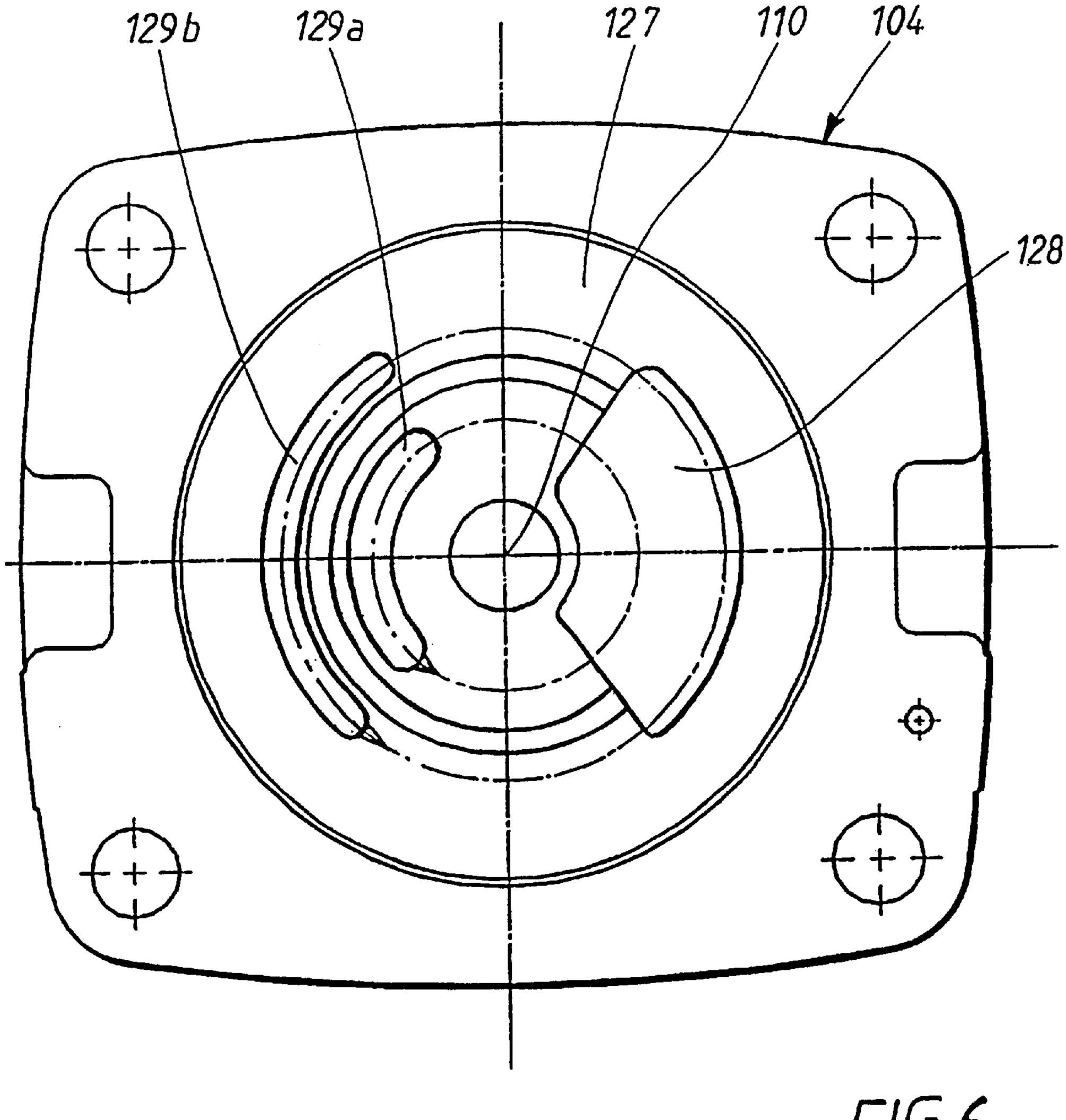


FIG.6

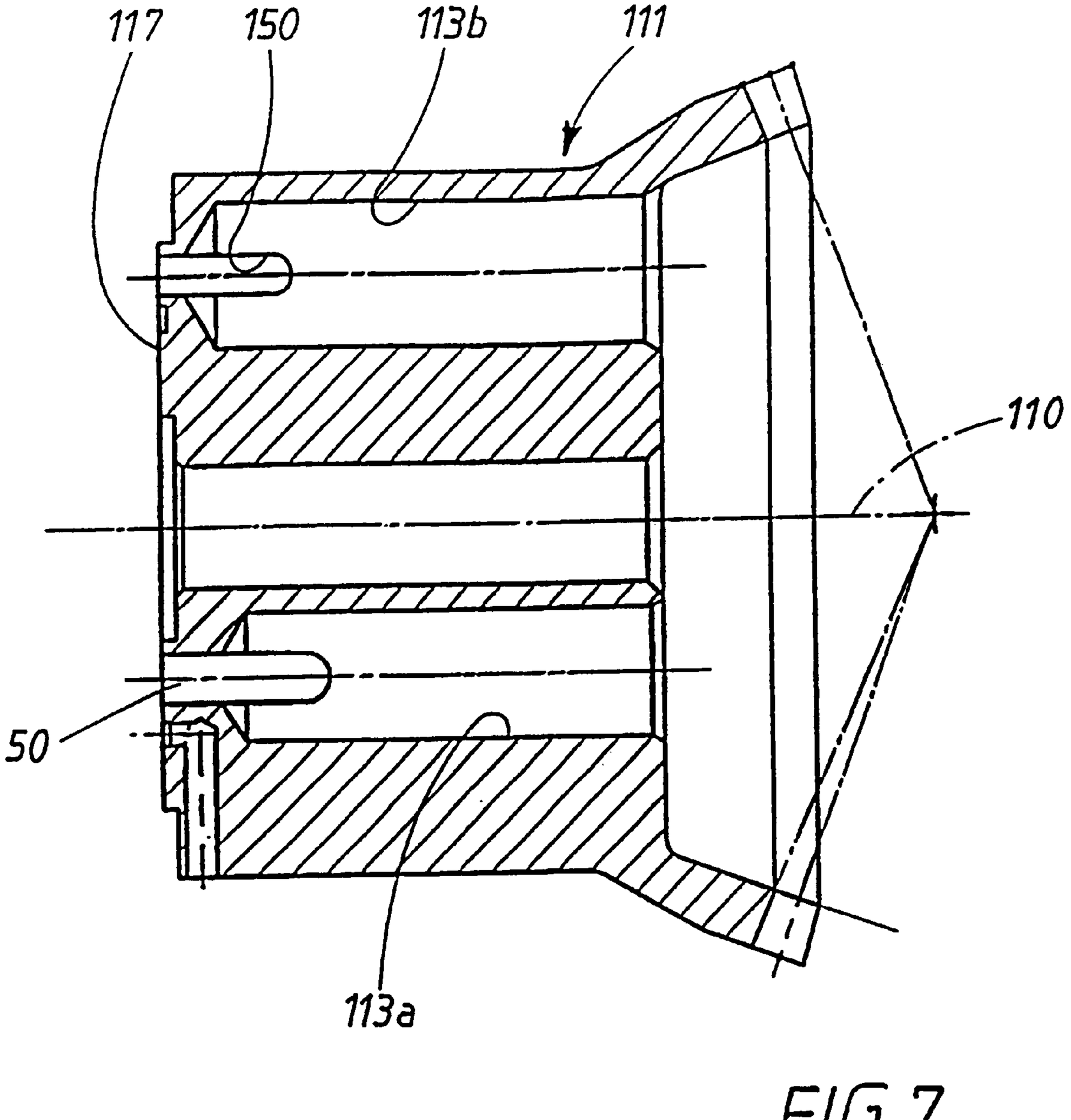


FIG. 7

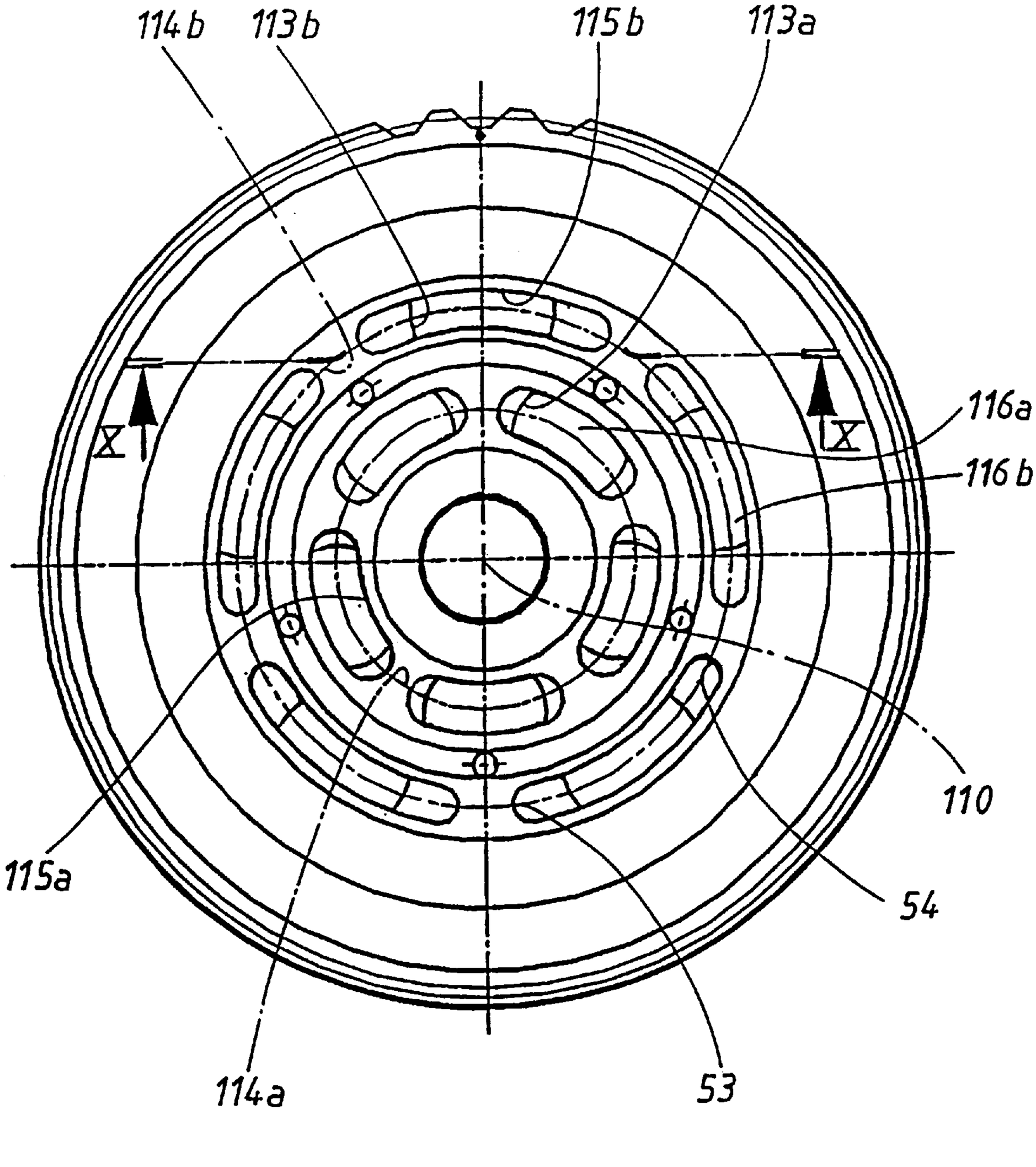


FIG. 8

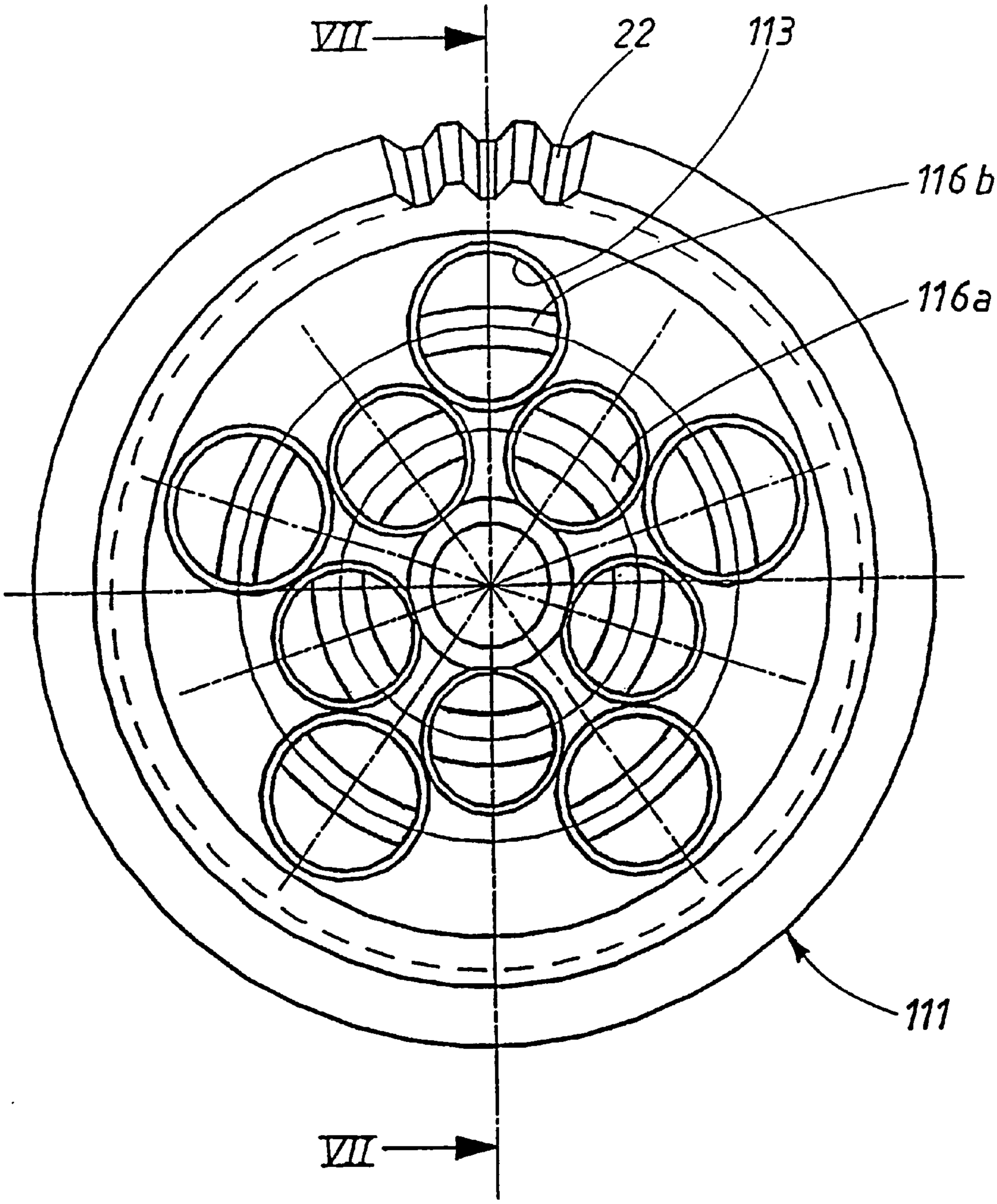


FIG. 9

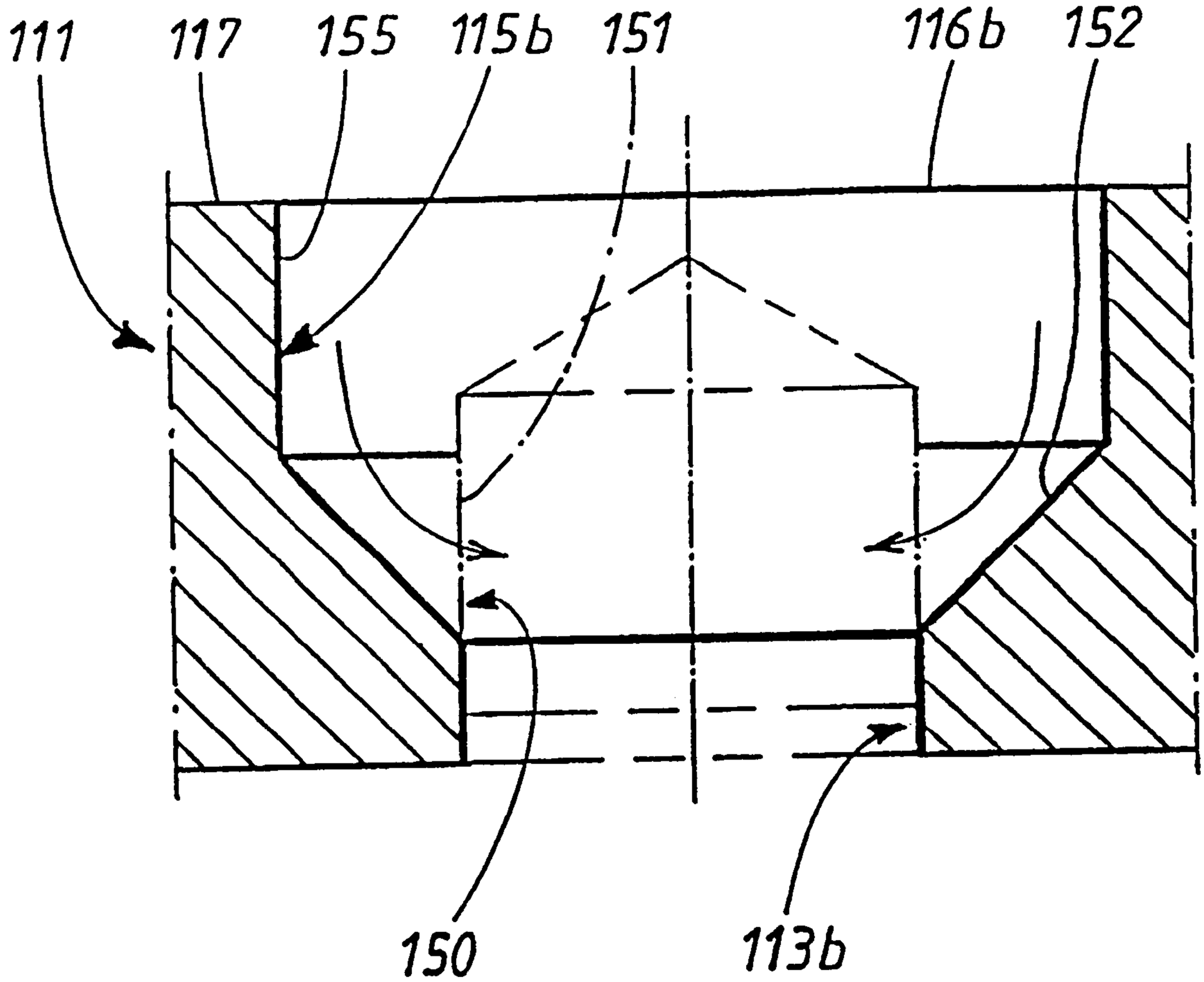


FIG.10

HYDRAULIC ROTATING AXIAL PISTON ENGINE

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a continuation of copending International Application No. PCT/SE99/00187, which designated the United States, and claims priority to Swedish Patent Application 9800412-0, filed Feb. 13, 1998.

BACKGROUND OF THE INVENTION

A hydraulic piston engine is known from European Patent Reference EP-A1-0 567 805, having a number of axial cylinders, which are circumferentially arranged in a rotatable cylinder barrel. Each of the cylinders is provided with a channel, which alternatingly communicates with an inlet port or an outlet port in a housing. From this reference it is apparent that the dimension of the channel in the radial direction of the cylinder barrel is considerably less than the diameter of the cylinder assuming that the channel has a circular cross sectional shape. The cross sectional area of the channel is also considerably less than the cross sectional area of the corresponding cylinder. The result is that the maximum flow capacity of the cylinders and the total capacity of the engine is not fully utilized.

SUMMARY OF THE INVENTION

The object of the present invention is to provide a hydraulic rotating axial piston engine of the above discussed type having maximum flow capacity for a certain volume of the cylinders.

The present object is obtained by means of an engine according to the present invention, where the channels open to the cylinders along the peripheral wall of each cylinder. The opening to the cylinders has substantially the same area as the area of the ports of the barrel and extends completely outside the nearest end position of the piston in each cylinder.

The hydraulic rotating axial piston engine of the present invention has a housing enclosing a cylinder barrel journalled in the housing for rotation around a barrel axis, and a number of circumferentially arranged cylinders in the barrel with a number of pistons reciprocating between two defined end positions. The pistons cooperate with an angled plate in order to obtain the reciprocating movement. The axial piston engine has an input/output shaft. The cylinder barrel has channels connecting each cylinder to ports in the cylinder barrel, the ports alternatively acting as inlet and outlet ports. The housing has at least one inlet and outlet channel, each having a kidney shaped port, facing towards the inlet and outlet ports of the cylinder barrel. The kidney shaped ports communicate with a number of the ports at the barrel. At least a number of the cylinder barrel ports extend in both directions outside the cylinders in the two circumferential directions of the cylinder barrel.

Further features of the present invention will become apparent to those skilled in the art upon reviewing the following specification and attached drawings.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** shows an axial section of a pump according to the present invention, according to a first embodiment;

FIG. **2** is a plan view of a connecting part in the first embodiment of the pump as seen separately from the inside;

FIG. **3** is an end view of a housing part of the pump according to FIG. **1**;

FIG. **4** is an end view of the connecting part in a second embodiment of the pump;

FIG. **5** is a cross sectional view of the pump along the lines V—V in FIG. **4**;

FIG. **6** is a plan view of the connecting part in the second embodiment of the pump as seen separately from the inside;

FIG. **7** is an axial section of a cylinder barrel of the pump according to the second embodiment;

FIG. **8** is an end view of the cylinder barrel as seen from the connecting part;

FIG. **9** is an end view of the cylinder barrel as seen from the opposite end; and

FIG. **10** is a partial section of the cylinder barrel along the lines X—X according to FIG. **8**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The hydraulic rotating axial piston engine according to a first embodiment of the present invention is shown in FIGS. **1–3** as an axial piston pump, indicated generally at **1**. The pump has a housing, indicated generally at **2**, which is comprised by at least two parts. Three parts are shown, namely a housing part **3** and a connecting part **4**, having connecting openings, namely an inlet opening **5** and an outlet opening **6** for connecting input and output conduits for hydraulic fluid to and from the pump respectively. A third part **7** of the housing is a support part for the input shaft **8** which is provided to be connected with a drive motor, not shown.

In FIG. **1** the general parts of the pump are shown. The pump is of a so-called "bent axis" type, having a first rotational axis **9**, forming a rotational axis for the input shaft **8**, and a second rotational axis **10** inclined relative to the first axis by an angle of for example 40°. The second rotational axis is an axis for a cylinder barrel **11** which is rotatably journalled in the housing. The cylinder barrel **11** has a number of axially extending pistons **12**, movable axially, i.e., substantially in parallel with the axis **10** in a reciprocating movement in a corresponding number of cylinders **13**. Cylinders **13** also extend axially with the axis **10**, and are circumferentially equally spaced along a circle line **14** (see FIG. **3**). Each cylinder **13** has a fluid passage or channel **15** with a port **16** in the planar end surface **17** of the cylinder barrel **11**. Each opening **16** has its largest length along the peripheral circle line **14**, and is kidney-shaped.

From FIG. **1** it is further apparent that each piston **12** has a piston rod **18** with a spherical head **19**. The spherical heads are supported in spherical bearing surfaces, forming recesses **20** in a swash plate **21**, which forms an integral part of the input shaft **8**. The spherical recesses **20** are rotatable around a radial plane which is angled relative to the radial plane of the cylinder barrel **11**. This results in the reciprocating movement of the pistons **12** and the pumping action according to a prior known principle, in order to create vacuum, i.e., suction in the inlet opening **5** and pressure in the outlet opening **6** (see for example U.S. Pat. No. 5,176,066).

Synchronizing means are arranged in order to synchronize the rotational movements of the cylinder barrel with the rotation of the swash plate **21**. In the shown example, the synchronizing means is made in the form of tooth gear formed by a tooth wheel rim **22** on the cylinder barrel cooperating with a tooth wheel **23** of the input shaft **8**. A support pin **24** supports the cylinder barrel **11** along the axis **10**. The support pin **24** cooperates with a shaft **25** which forms the rotational axis **10** and projects through a bore **26**

of the cylinder barrel. The shaft **25** is supported in a bore **26'** of the connecting piece **4** of the housing.

FIG. **2** shows the connecting part **4** of the housing separately and from the inside. The connecting part **4** has on its inside a substantially planar, circular surface **27** which in the mounted position faces the planar surface **17** of the cylinder barrel **11**. The two planar surfaces **17, 27** are arranged to contact each other with a sealing fit. On its inside the connecting part **4** is provided with one inlet port **28** and one outlet port **29**, each of which are kidney-shaped. The inlet port **28** communicates through a channel **5'** (FIG. **1**) with the inlet opening **5**, and the inner outlet port **29** communicates through a separate channel **6'** with the outlet opening **6** on the outside of the connecting part **4**.

The inlet and outlet ports **28, 29** extend along a peripheral circle line **30** which has a corresponding radius as the circle line **14** of the openings **16** of the cylinder barrel **11**. The inlet and outlet openings **28, 29** extend on each half of the circle line **30**, separated by a main plane **31** extending through the connecting part **4**. The inlet and outlet port **28, 29** are further divided by a second main plane **32** extending 90° relative to the first main plane **31**. The inlet and outlet ports **28, 29** further extend along the circle line **30** along a predetermined peripheral angle, which in the shown example is somewhat larger for the inlet opening **5** than for the outlet opening **6**, and are arranged so that simultaneously more than one cylinder port **16** communicates with the inlet port **28** and the outlet port **29**, respectively. The inlet and outlet ports **28, 29** can be provided with slit extensions as a t**33**, the ends of which determine the total angular extension of the inlet and outlet ports.

In the above first embodiment there has been described a so-called single pump, serving a single hydraulic system by means of one single outlet pressure opening **6**. Therefore there is one single fluid passage and one single inner port **29**. Consequently the cylinder barrel has one single set of cylinders circumferentially positioned along one single peripheral circle line **14**.

In a second embodiment there is shown a so-called double pump, serving two independent hydraulic systems. The second embodiment will now be described with reference particularly to FIGS. **4–9**. From the end view of the connecting part **104** it is apparent that in the double pump there are two outlet pressure openings **106***a*, **106***b*. The inlet suction opening **105** is dimensioned to receive sufficient flow of fluid in order to serve the two outlet openings and the corresponding hydraulic systems. By means of the section in FIG. **5** the extension of the fluid passages **105'** and **106'***a* are shown as an example, as well as the inlet port **128** and one of the outlet ports **129***a*. Also the planar surface **127** is shown facing the end surface of the cylinder barrel.

From FIG. **6** it is apparent that the inlet port **128** has considerable radial extension contrary to the outlet ports **129***a*, **129***b*, and all extend substantially concentrically relative to the second rotational axis **110**, which is the axis for the cylinder barrel **111**, as shown in FIGS. **7–9**.

From FIGS. **7–9** it is apparent that in the second embodiment there are two sets of axial cylinders **113***a*, **113***b* which are circumferentially arranged around the rotational axis **110**. An inner set of cylinders **113***a* are equally spaced along an inner circle line **114***a*; and an outer set of cylinders **113***b* are equally spaced along an outer circle line **114***b*.

Especially when having two circumferentially arranged sets of cylinders **113***a*, **113***b* the radial space in the planar end surface **117** facing the planar inner surface **127** of the connecting piece is very limited, as the radially inner set of cylinders has to communicate with the radially inner pressure port **129***a*, and the radially outer set of cylinders **113***b* has to communicate with the radially outer pressure port **29***b*. However, the cylinder ports **11 6***a*, **11 6***b* are highly extended along their circle lines **114***a*, **114***b* respectively. This is especially expressed in the outer set of cylinder ports **116***b*. It is particularly important that the cross sectional area of the cylinder barrel ports **116***a*, **116***b* is as large as possible and not too much smaller than the cross sectional area of the cylinders. It is also important that the cylinder barrel ports **116***a*, **116***b* do not reduce the flow capacity of the pump as a whole.

However, it is not only the cross sectional area of the cylinder barrel ports **116***a*, **116***b* in the cylinder barrel end surface that is important for the flow capacity. From the sectional view of FIG. **10**, the section through one of the radially outer cylinder port channels **115***b* is shown. In the radially outer cylinder port channels, it is especially visible that according to the present invention the channel **115***b* has an inner opening **150** to the cylinder which extends along the peripheral wall **151** of the cylinder, and has substantially the same area as the area of the ports of the barrel. Furthermore, the cross sectional area of each channel **115***b* is nowhere less than the area of the opening **150**. Furthermore, as seen best in FIG. **7**, the opening **150** has a contour line which is U-shaped. It is apparent from FIG. **10** that the opposite walls **152** at the end portions **153, 154** converge in direction towards the inner opening **150** of the channel **115***b*. Walls **152** pass near the opening **150** over to a wall portion **155** which extends to the planar end surface **117** of the cylinder barrel **111**. The transition between wall **152** and the wall portion **155** forms an angle exceeding 90 degrees.

By means of the shape and the arrangement of the cylinder port channels **115***b*, the channels will not form a limitation of the flow capacity of the pump which substantially will be determined by the volume of the cylinders **113***a*, **113***b*.

The extension of the cylinder barrel ports **116***a*, **116***b* along their peripheral circle lines **114***a*, **114***b*, and also the corresponding peripheral extension of the suction port **128** and pressure ports **129***a*, **129***b*, determines the time sequence and operation of the cylinder barrel ports as alternatingly suction ports and pressure ports. The ports are in syncronization with the angular positions in the end positions, i.e., for upper dead point (UPD) and lower dead point (LDP) for the pistons in a principally prior known manner. Further, the opening extends along the peripheral wall of the cylinders along at least the outer circle line **114***b* completely outside the nearest end position of the piston in the cylinder. However, in the example as shown in FIGS. **8** and **9**, the openings extend along the peripheral wall of the cylinders along both circle lines **114***a*, **114***b*.

The design of the cylinder barrel channels has been described and shown with reference to the second embodiment with the double pump. However, the same principle is applied to the single pump in order to achieve a maximum of capacity for a certain cylinder volume. The detailed shape of the channel can be modified without changing the principle of the present invention. For example, the peripheral extension as described and shown can be excluded for the openings of the cylinders along the inner circle line **116***a*.

What is claimed is:

1. A hydraulic rotating axial piston engine, comprising:

a housing enclosing a cylinder barrel journalled in said housing for rotation around a barrel axis, and having a number of circumferentially arranged cylinders with a

number of pistons reciprocating between two defined end positions, said pistons cooperating with an angled plate in order to obtain said reciprocating movement, said axial piston engine having an input/output shaft, said cylinder barrel having channels connecting each cylinder to ports in the cylinder barrel, said ports alternatively acting as inlet and outlet ports, said housing having at least one inlet and outlet channel, each having a kidney shaped port facing towards said inlet and outlet ports of said cylinder barrel, said kidney shaped ports communicating with a number of said ports of said barrel, at least one of said cylinder barrel ports extending in both directions outside the cylinders in the two circumferential directions of the cylinder barrel, wherein said channels have an opening to said cylinders along a peripheral wall of each cylinder, said opening to said cylinders having substantially the same area as the area of the ports of the barrel and extending completely outside the nearest end position of said piston in each cylinder.

2. A hydraulic rotating axial piston engine according to claim **1**, wherein said engine is a pump, driven by means of a motor, applying a torque to the input shaft.

3. A hydraulic rotating axial piston engine according to claim **2**, wherein said input shaft is angled relative to the axis of the cylinder barrel rotatable with said angled plate.

4. A hydraulic rotating axial piston engine according to claim **3**, wherein said cylinder barrel ports are circumferentially arranged along two concentric circle lines and communicate with two separate kidney shaped ports in the housing.

5. A hydraulic rotating axial piston engine according to claim **1**, wherein said opening has a U-shaped contour line.

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